disposal alternative involve both time required to meet steady-state conditions and the question of whether the target goals (i.e., concentrations) could be met.

Off-Site Disposal

Model predictions, supported by the site-specific data, indicate that long-term ground water concentrations adjacent to the river (background concentrations for the off-site disposal alternative) would be protective for acute and chronic exposure scenarios for all but the worst-case pH and temperature conditions without any consideration of dilution from the surface waters.

No Action Alternative

It is possible that the No Action alternative would meet the target goal considering the number of uncertainties involved. For example, a factor-of-2 decrease in the 6-mg/L ammonia concentration in ground water predicted at steady state would result in meeting the 3-mg/L target goal. A factor-of-2 decrease in predicted concentrations is within the lower range of uncertainty.

It is clear that if ground water concentrations comply with remediation objectives, surface water concentrations should comply as well. Therefore, on the basis of site-specific data and a study of the site conditions, DOE has a reasonable degree of confidence that protective conditions would be met and maintained both during the operation of the remedial action (75 to 80 years) and following achievement of water quality goals. Monitoring would confirm performance to meet target concentrations.

2.4 No Action Alternative

Although DOE would not remediate contaminated materials or ground water under this alternative, DOE would likely complete tasks necessary to secure the site to minimize the potential for accidents. For example, power would be turned off and equipment would be removed. This alternative is analyzed to provide a basis for comparison to the action alternatives and is required by NEPA regulations (40 CFR 1502.14[d]).

Under the No Action alternative, DOE would not remediate on-site surface contamination, which includes the existing tailings pile, contaminated materials and buildings, and unconsolidated soils. The existing tailings pile with its interim cover would not be capped and managed in accordance with 40 CFR 192 standards; this consequence of the No Action alternative would conflict with the requirements of the Floyd D. Spence Act. In addition, no site controls or activities to protect human health or the environment would be continued or implemented. Public access to the site would be unrestricted. All site activities, including operation and maintenance activities, would cease. Vicinity properties located close to the site and near the town of Moab, including residences, commercial and industrial properties, and vacant land, would also not be remediated.

Initial and interim ground water actions would not be continued or implemented. DOE would abandon all ongoing and planned activities designed to protect endangered species and prevent discharge of contaminated ground water to the Colorado River. No further media sampling or characterization of the site would take place.

A compliance strategy for contaminated ground water beneath the site would not be developed in accordance with standards in 40 CFR 192. Contaminated ground water would discharge indefinitely to the backwater areas of the Colorado River, and ammonia concentrations would continue to exceed protective levels. No institutional controls would be implemented to restrict the use of ground water, and no long-term surveillance and maintenance would take place. Because no activities would be budgeted or scheduled at the site, no further initial, interim, or remedial action costs would be incurred.

2.5 Alternatives Considered But Not Analyzed

This section addresses on-site and off-site alternatives, including locations, that were initially considered on the basis of preliminary assessment. However, they were eliminated from detailed evaluation for the EIS.

2.5.1 On-Site Alternatives

On-site alternatives for surface remediation that were initially considered included (1) stabilize-in-place, (2) solidification, (3) soil washing, and (4) vitrification. All but stabilize-in-place were eliminated from detailed evaluation. The rationale for elimination is discussed below. Ground water compliance alternatives were evaluated in the SOWP (DOE 2003b), which evaluates the compliance strategies and serves as the basis for the strategy proposed in Section 2.3.

2.5.1.1 Solidification

This alternative involves adding a stabilizing reagent to a soil or sediment. The reagent fills the interstitial spaces, blocking the flow of water and other fluids into these spaces and reducing contact and leaching of contaminants. A study of polyethylene macroencapsulation conducted by DOE and Envirocare at the Envirocare site near Salt Lake City showed that this technology could be applied to reduce leachate from radioactively contaminated lead bricks.

However, a study of seven solidification/stabilization reagents for treatment of contaminated sediments at the New Bedford Harbor Superfund site in Massachusetts did not give encouraging results. Concentrations of RCRA Toxicity Characteristic Leachate Procedure metals, particularly barium, copper, and zinc, actually increased in leachate generated from a number of post-treatment samples (EPA 2001).

The current cost of the treatment system used at Envirocare (excluding the costs of the initial treatability studies that resulted in a viable technology) was estimated at $90 to $100 per cubic foot ($ft^3$) based on a demonstration performed on waste streams from 23 DOE sites (FRTR 2001). The estimated total volume of contaminated tailings and soils at the Moab site is approximately 8.9 million yd^3, or 240 million ft^3. Thus, the cost of remediating the Moab site using Envirocare macroencapsulation would be $22 billion to $24 billion. Macroencapsulation is inherently an ex situ process; therefore, this cost would be in addition to the cost of excavating the entire volume of contaminated tailings and soil. Because the solidified material would remain classified as RRM, it would still have to be disposed of as a radioactive waste. Additional disposal costs were not estimated because of the excessive costs associated with the treatment. Therefore, this alternative was eliminated from further assessment under this EIS.

2.5.1.2 Soil Washing

Notwithstanding the name, most soil-washing processes do not actually wash soils. Rather, they use water, sometimes combined with chemical additives, to separate contaminated soils into contaminated and clean constituents. Contaminants tend to bind to silt and clay. Soil-washing processes separate silt and clay from sand and gravel particles that constitute the bulk of most contaminated soils. The silts and clays, which contain the contaminants, must then be treated by other means before disposal. The sand and gravel can be disposed of as nonhazardous material. Soil washing, then, is a waste volume-reduction technology. It can be effective, resulting in volume reductions of as much as 90 percent.

Soil washing has been used at a number of Superfund sites, notably at the King of Prussia Technical Corporation site in 1993, where 19,200 tons of metal-contaminated soil and sludge were treated. The treated soil (sand and gravel) from the King of Prussia site met or exceeded all the treatment standards (EPA 1995).

Ashtabula, Ohio, is a DOE site where soil washing was used to treat 40,000 tons of soils commingled with depleted uranium. This application more nearly approximated true “soil washing” because it used a chemical extraction to leach the uranium from the soil. The results of this deployment appear to be mixed, although the volume reduction was nearly 98 percent (DOE 2001a).

Technical feasibility may be a serious obstacle to the use of soil washing at the Moab site. The uranium at the Moab site is chemically bound to the tailings because it occurs naturally in the ore, and the tailings are the by-product of the milling process. The uranium remaining in the tailings is that which remained bound to the substrate after the leaching process was used at the mill. It would likely be difficult to remove the uranium in a second stage of processing. Furthermore, a significant portion of the Moab tailings consists of slimes, which are difficult to handle in physical processes and do not disperse readily. The soil-washing systems used to date have relatively low capacities. The King of Prussia system operated at 25 tons per hour, so it would require 54 years to treat the Moab pile, assuming continuous operation. The Ashtabula system operated at 10 tons per hour, a rate that would require 136 years to treat the Moab pile. Pulse Technology, a private firm marketing a soil-washing technology developed with Russian aid, offers a stationary system that can process up to 90 tons per hour. This would treat the Moab pile in 15 years with no allowance for downtime. Because residual contamination would remain after soil washing, the resulting waste would still have to be managed and disposed of as radioactive waste.

Soil washing is an expensive technology. The project cost at the King of Prussia site was $7.7 million, or $401 per ton of soil (EPA 1995). The unit treatment cost at Ashtabula was estimated at $370 per ton (DOE 2001a). Either of these figures, if extrapolated to the total volume of more than 11 million tons of contaminated tailings and soils at the Moab site, results in a total treatment cost of more than $4 billion. The lowest cost suggested by EPA for soil washing is $90 per ton (DOE 2001a), equivalent to $1 billion for the Moab site. To make soil washing economically feasible at the site, the unit costs would have to be an order of magnitude lower than those reported at the other sites where that technology has been used. There is no indication that such a reduction could be achieved.

2.5.1.3 Vitrification

This treatment alternative uses electricity to heat contaminated soils to their melting points in place, then allows the melted soils to cool as glass. The high temperatures required for vitrification (quartz melts at 1,610 °C [2,930 °F]) destroys many contaminants, and contaminants that are not destroyed are encapsulated in the glass.

Vitrification has been used at a number of DOE and other sites to treat small quantities of high-level radioactive waste. It is particularly useful for treatment of high-level liquid wastes. The Savannah River (Pickett et al. 2000) and Hanford Sites (62 FR 8693–8704 [1997]) are using vitrification for this purpose. An in situ vitrification (ISV) treatment system was successfully used to treat contaminated soils and sediment at the Parsons Chemical/ETM Enterprises Superfund site (EPA 1997). Oak Ridge National Laboratory (ORNL) has successfully demonstrated a transportable vitrification system for ex situ treatment of contaminated soils (DOE 1998). An in situ pilot test at Brookhaven National Laboratory in 1996 was less successful and, as stated in the report on that test, "raised concerns about the effectiveness of ISV" (DOE 1996b).

The quantities of wastes treated by vitrification have been small compared with the volume of contaminated tailings and soils at the Moab site. The ORNL ex situ demonstration (DOE 1998) treated about 8 tons of mixed waste, and the Parsons Chemical/ETM project (EPA 1997) treated approximately 3,000 yd^3 of soils and sediment. The estimated volume of solid material at the Moab site is 8.9 million yd^3.

Partly because of the relatively small volumes treated, the reported unit costs of ISV projects have been high.

- The ISV project at the Parsons Chemical/ETM Enterprises Superfund site in Grand Ledge, Michigan, which treated approximately 3,000 yd^3 of contaminated soils and sediments in 1993 and 1994, reported a cost of $270 per cubic meter (equivalent to $353 per cubic yard).
- DOE's report on ISV reported average costs of $375 to $425 per ton for projects at Parsons, ORNL, Wasatch, and a private Superfund site.
- "High Temperature Plasma Vitrification of Geomaterials" (Mayne and Beaver 1996) reported a range of operating costs of $308 to $695 per cubic meter (equivalent to $403 to $909 per cubic yard).

The total treatment cost of the ORNL ex situ transportable vitrification system was calculated at $8 to $15 per kilogram ($18 to $33 per pound).

Applying the average of the costs of the in situ processes (excluding the ORNL ex situ transportable vitrification system) to the total volume of the tailings and contaminated soils at the Moab site yields an estimated total cost of more than $4 billion for remediation of the site using ISV. Some economy of scale would be realized in a project the size of Moab. However, the most significant cost element in a vitrification process is electricity. DOE used an estimated unit cost of $0.05 per kilowatt hour to derive the cost range for vitrification projects, and it is highly unlikely that the cost of electricity for the Moab project would be significantly lower than this value. To make vitrification economically feasible at Moab, the unit costs would have to be more than an order of magnitude lower than those reported at the other sites where that technology has been used. The consistency between the reported unit costs for the various ISV projects suggests that an order of magnitude reduction is unlikely. In addition, as with other treatment alternatives, this waste would still need to be managed and disposed of as a radioactive waste.

2.5.1.4 *On-Site Relocation*

Moving the pile to another location on the Moab site was considered but dismissed as an alternative. DOE is already analyzing an on-site disposal alternative and there do not appear to be any advantages offered by relocating the tailings elsewhere on the site. Any alternate locations on the Moab site would result in more of the tailings pile/disposal cell lying in the 100-year floodplain of either the Colorado River or Moab Wash, thereby increasing the risk of flooding and decreasing cell integrity. One of the major objections to the existing pile is its proximity to the residents of Moab, to the Colorado River, and to Arches National Park. Moving the cell to a different location on the Moab site would not remedy these concerns and is likely to result in the relocated cell being closer to one of these three receptors. Although a relocated on-site disposal cell could be designed with a liner, it would continue to be located directly over an aquifer that feeds the Colorado River. Potential liner failure would pose a threat of contamination of the ground water and thus the Colorado River.

2.5.1.5 *Removal of Top of the Pile*

Because ammonia is the primary contaminant of concern and because it appears to be concentrated in the top of the pile due to the presence of a salt layer, some commentors have suggested that an alternative disposal strategy might be to remove the top portion of the pile (for example, the top 10 ft) for off-site disposal and cap the rest of the pile in place. However, DOE does not believe such a strategy offers potential advantages sufficient to warrant full analysis. While acknowledging that a salt layer may exist in the upper part of the pile and that leaching of ammonia from this layer could result in a temporary resumption of nonprotective surface water quality, modeling suggests that the potential impacts to surface water and aquatic species from salt layer leaching would not occur for at least 1,000 years. Moreover, partial removal of the pile would be the worst alternative in terms of proliferation of sites requiring long-term monitoring and stewardship. To some degree, removal and transportation of just the top of the pile would entail all of the unavoidable adverse impacts associated with full off-site disposal but would not result in any of the benefits to be accrued at the Moab site through full off-site disposal. DOE does not believe the alternative offers any compelling benefits in terms of impact or cost.

2.5.2 Off-Site Alternatives

2.5.2.1 *Off-Site Surface Locations*

Several off-site locations were considered for surface disposal of contaminated materials. All sites are within the state of Utah and included the following:

- Envirocare
- ECDC
- Green River
- Box Canyon
- Rio Algom
- Cisco site
- Whipsaw Flats
- Summo Minerals Lisbon Valley

These alternate locations for surface disposal were eliminated from further consideration on the basis of the following factors:

The licensed capacity of the Envirocare site is only half of the volume of tailings at the Moab site that would require disposal. Additional capacity for the tailings would require an amendment to the existing license from the State of Utah and an environmental evaluation. In August 2004, NRC transferred licensing authority to the State of Utah for the regulation of the possession of by-product material by persons. The tailings-transport distance to the Envirocare site would be over 200 miles (170 miles farther than the Crescent Junction site). Transportation costs associated with disposal of the tailings at Envirocare would be prohibitive.

ECDC formally withdrew its site from consideration shortly after the Notice of Intent To Prepare an EIS was published. At the Green River site, the location of the Green River floodplain in the northern portion of the site would limit placement of a disposal cell to the area south of the Probable Maximum Flood (PMF [see definition in Chapter 1.0]) boundary. The site is also bounded by I-70, which would severely restrict the space available for cell construction and disposal. The Box Canyon site would be limited by several small washes formed by surface runoff at the site, and the space is limited for a tailings pile. In addition, the Box Canyon site is located in an area frequented by tourists and outdoor recreationists, making it incompatible with a tailings disposal facility.

The Rio Algom facility was not considered a viable disposal site because (1) shallow, contaminated ground water exists in the Burro Canyon aquifer, (2) the ACL application has already been submitted to NRC for approval and termination of the license, contingent on existing conditions, and (3) adjacent property has already been acquired to provide an institutional control over the site-related contamination in ground water, and it may be impractical to expand farther.

The Cisco site is located 30 miles farther from Moab than the Crescent Junction site, and transportation costs would be higher compared to those for the Klondike Flats or Crescent Junction sites. Also, the Cisco site does not offer disposal criteria that are better than those at the Klondike Flats site. The Whipsaw Flats site is close to Arches National Park, and NPS personnel have opposed this location because the disposal site would be visible from portions of Arches National Park. In addition, this site would not offer any advantages over the Klondike Flats or Crescent Junction sites and would be more difficult to access than either the Klondike Flats or Crescent Junction sites.

The Summo Minerals Lisbon Valley site was proposed by a private copper mining company who suggested that the Moab tailings could be co-deposited with copper ore heap-leach residues. The Lisbon Valley site is located roughly the same distance from Moab as the Klondike Flats site, but the hydrogeology is less favorable.

Comments received in scoping meetings suggested several other off-site alternatives or related actions. These were considered but dismissed as described in the following discussions.

Railroad to White Mesa Mill Site—DOE considered but dismissed construction of a new railroad line from the Moab site to White Mesa Mill as an alternative because of the potential for extensive environmental impacts, technical difficulty, and cost. Minimum construction costs for a new rail line are typically in the range of $1 million to $3 million per mile, depending on terrain. In areas where the grade exceeds 1 to 2 percent, the line would have to be routed to avoid these grades, thereby adding to the total mileage, or the railbed would have to be graded to 1 to 2 percent, which would add to the cost and terrestrial impacts. A railroad bridge crossing the Colorado River would be a major additional expense and would require extensive and unforeseeably complex and lengthy permitting issues and potential delays in completing the construction. Acquisition or leasing of undisturbed land, much of it privately held, would be an additional expense, as would the necessary land surveys and road crossings, and there would be no guarantees that the required land could be secured without condemnation proceedings. DOE estimates that capital construction costs of a new 90- to 100-mile railroad from the Moab site to the White Mesa Mill site would exceed $150 million, including land surveys/acquisition and track, bridge, and road crossings construction. This is almost twice the projected capital construction costs for building a pipeline. Based on these higher capital construction costs, uncertainties surrounding the permitting process, and the likelihood of significant environmental impacts, this alternative was dismissed from further consideration.

Old Mines—Disposing of the contaminated tailings in old mines was dismissed from consideration because (1) no single mine in the region had sufficient volume to contain the contaminated material from the Moab site, (2), mines are typically excavated by blasting, and consequently can be structurally and geologically unstable, and (3) old mine shafts could also be susceptible to explosions, poisonous gas, and cave-ins. The use of mines under these conditions would pose serious logistical and worker occupational safety and health concerns.

Grand County Landfill—Using the Grand County landfill or allowing Grand County to own or direct operations of the cleanup area was dismissed because the landfill is neither permitted for nor technically designed for radioactive waste.

River Rerouting—Rerouting the Colorado River away from the Moab site was dismissed as an alternative because of the broad range of adverse and irreversible environmental impacts to the Matheson Wetlands Preserve that such an undertaking would entail.

Land Use—Converting the site into a golf course was suggested but is not considered an alternative remediation action. Rather, it is a potential future land use suggestion that will be considered at a later time.

Use of Contaminated Water—Contaminated ground water could possibly be used to augment the slurry pipeline recycle makeup water requirements or, depending on schedule, to augment the nonpotable requirements for the initial pipeline slurry. However, the anticipated 150 gpm of pumped contaminated ground water would be less than 40 percent of the required 409 gpm of makeup water (see Table 2–12). If the pipeline option were implemented, the effluent discharge options discussed in Section 2.3.3 would be evaluated, and a preferred option or combination of options would be selected for more detailed technical and engineering review. Use of contaminated water to augment the slurry water requirements would be evaluated at that time.

2.5.2.2 Disposal in Mined Salt Caverns

In late 2003, DOE considered an option to dispose of the Moab mill tailings in solution-mined salt caverns either at the Moab site or off site at two potential locations. Conceptually, disposal caverns would be created by solution mining in the salt beds of the Paradox Formation beneath the Moab site or at other possible locations, such as the commercial potash mine site approximately 6 air miles downstream from Moab. This option would involve withdrawing Colorado River water for the solution mining process; the water would become saturated with salt, generating brine that would have to be disposed of by deep well injection or solar evaporation or perhaps by use in the potash mining operations. Appendix E presents DOE's evaluation of this alternative approach.

Disposal in mined salt caverns is an unproven approach to uranium mill tailings disposal that would require immense amounts of Colorado River water (approximately 1,700 gpm of fresh water, roughly 880 million gallons per year or 73 million gallons per month) for a 20-year period to perform solution mining activities. DOE does not currently own the rights to withdraw this much water, and if they could be purchased, DOE would be required to pay water depletion fees associated with compensation of existing water right holders because of impairment.

DOE's programmatic experience with the complexity of implementing a first-of-a-kind unproven disposal technique for radioactive waste indicates that implementation of this option could be 3 or 4 times as long as all other alternatives (up to a few decades to go operational, a 20-year operations time frame, and a project life cycle range of multiple decades). Technical, geological, hydrological, seismological, legal, economic, and operational uncertainties present a real potential for substantial schedule and cost growth over current estimates. More specifically, these technical and operational uncertainties include (1) the location of favorable geologic strata that could be used for disposal of the brine by deep well injection and the rate and extent that brine could be injected; (2) the location, depth, and configuration of the caverns to be solution mined in the Paradox Formation; (3) the long-term performance of salt caverns in isolating the mill tailings; (4) the private/government business model that could allow use of the salt or brine, (5) the consumption of significant quantities of Colorado River water, which may be more than is available under DOE's water rights and possibly more than what would be acceptable under the recovery program for endangered fish; (6) the high potential cost (approximately $892 million to $1.3 billion); and (7) high potential for cost growth well beyond the range identified for other alternatives.

Resolving these uncertainties sufficiently to determine whether this alternative would be technically feasible and cost-effective would require a significant investment in additional studies. Such studies would include injection well testing, subsurface characterization, salt cavern performance modeling, an assessment of legalities, and an overall system performance assessment. The studies could require several to tens of millions of dollars and many years to complete, with no guarantee that the investment would demonstrate that this alternative is technically viable or offers substantive advantages to DOE or the public relative to the other alternatives being considered. Because the available data are not sufficient to provide the basis for a decision of this magnitude, DOE would need to delay the EIS to obtain this information.

An advantage of the solution-mixed salt cavern approach is the potential for longer-term isolation and more protection than that offered by other alternatives. Other advantages are that (1) salt cavern disposal would produce the least long-term environmental impact because no surface footprint would remain at the conclusion of the disposal period, and (2) this approach provides another disposal option for contaminated ground water for 50 of the 75 to 80 years required for active ground water remediation.

However, on the basis of the evaluation of this option and review by the 12 cooperating agencies and given the technical, legal, and economic uncertainties associated with this unproven technical approach, DOE's past experience, and the potential advantages with respect to the existing alternatives and the disadvantages, DOE has concluded that this option is not "practical or feasible" and has therefore decided not to include salt cavern disposal as a reasonable alternative in the EIS.

2.6 Description and Comparison of Alternatives and Environmental Consequences

Section 2.6.1 summarizes the potential impacts (both adverse and beneficial) to the physical, biological, socioeconomic, cultural, and infrastructure environment that could occur under the on-site disposal alternative, the off-site disposal alternative, and the No Action alternative. Human health impacts are also summarized. This section also compares the major differences in impacts among the alternatives and the differences among transportation modes under the off-site disposal alternative. It is based on the consequences, including assumptions and uncertainties, identified in detail in Chapter 4.0 of the EIS. Section 2.6.2 summarizes the potential impacts (both adverse and beneficial) to the physical, biological, socioeconomic, cultural, and infrastructure environment that could occur at the potential borrow areas. Section 2.6.3 identifies areas of uncertainty in DOE's analyses and the potential ramification of those uncertainties on decision-making. Section 2.6.4 recognizes that there are opposing views on a few issues, characterizes those opposing views, presents DOE's position on the issues, and discusses the implications of these issues to decision-making.

2.6.1 Impacts Affecting the Moab Site and Vicinity Properties, Transportation Corridors, and Off-Site Disposal Locations

Geology and Soils. Under either the on-site disposal alternative or the No Action alternative, the combination of the processes of subsidence and incision would slowly affect the tailings pile by lowering it in relation to the Colorado River. This impact would not occur under the off-site disposal alternative because the pile would be removed. There is also the potential for minor geologic instabilities in areas surrounding the White Mesa Mill site. Sand and gravel resources beneath the Moab site would be unavailable for commercial exploitation under all the alternatives due to residual contamination, even after surface and ground water remediation was complete. There are no known geologic resources beneath any of the alternative off-site disposal cell locations that would be affected by the proposed actions. Under any of the action alternatives, approximately 234,000 tons of contaminated site soil would be excavated and disposed of with the tailings.

Air Quality. Under the on-site and off-site disposal alternatives, emissions of particulate matter would occur during construction and excavation operations and would require dust control measures. Operation of vehicles and construction equipment would result in emissions of criteria air pollutants. Air pollutant emissions would be greater under the off-site disposal alternative as compared to the on-site disposal alternative, primarily because of the need to transport the tailings. Among the alternative off-site locations, transporting the tailings to the White Mesa Mill site would result in the largest volume of air pollutants because of the longer distance to be traveled. With respect to the alternative modes of transportation under the off-site disposal alternative, transportation of the tailings by slurry pipeline would involve less air pollution than would either truck or rail transportation due to the lower level of exhaust emissions. Such emissions would be greater for truck versus rail transportation. However, none of the proposed action alternatives would result in air emissions that exceed National Ambient Air Quality Standards or Prevention of Significant Deterioration increment limits.

A detailed human health analysis that includes health impacts associated with air quality is provided in Appendix D of the EIS. The design and construction of the disposal cell cover at all disposal sites would ensure that radon emissions would be below applicable health standards. Under any of the proposed action alternatives, long-term air emissions at the Moab site from technologies evaluated for active ground water remediation would not exceed health standards for workers or the public.

Ground Water. Ground water remediation would be implemented under both the on-site and off-site disposal alternatives. Under the on-site and off-site disposal alternatives, supplemental standards would be applied to protect human health. The supplemental standards would include institutional controls to prohibit the use of ground water for drinking water. Under the on-site disposal alternative, the tailings pile would be a continuing source of contamination that would maintain contaminant concentrations at levels above background concentrations in the ground water and, therefore, potentially require the application of supplemental standards (institutional controls) in perpetuity to protect human health. Under the off-site disposal alternatives, contaminant concentrations in the ground water under the Moab site would return to background levels after 150 years, by which time active ground water remediation would have been complete and supplemental standards would no longer be needed. The tailings pile would not be a continuing source of contamination to ground water under the off-site disposal alternative.

DOE estimates that meeting its target ground water remediation goal of 3 mg/L of ammonia in ground water would require active ground water remediation at the Moab site for 80 years under the on-site disposal alternative and for 75 years under the off-site disposal alternative (Figure 2–45). DOE has determined that this duration of treatment would ensure that water quality in the Colorado River would remain protective after ground water treatment was terminated.

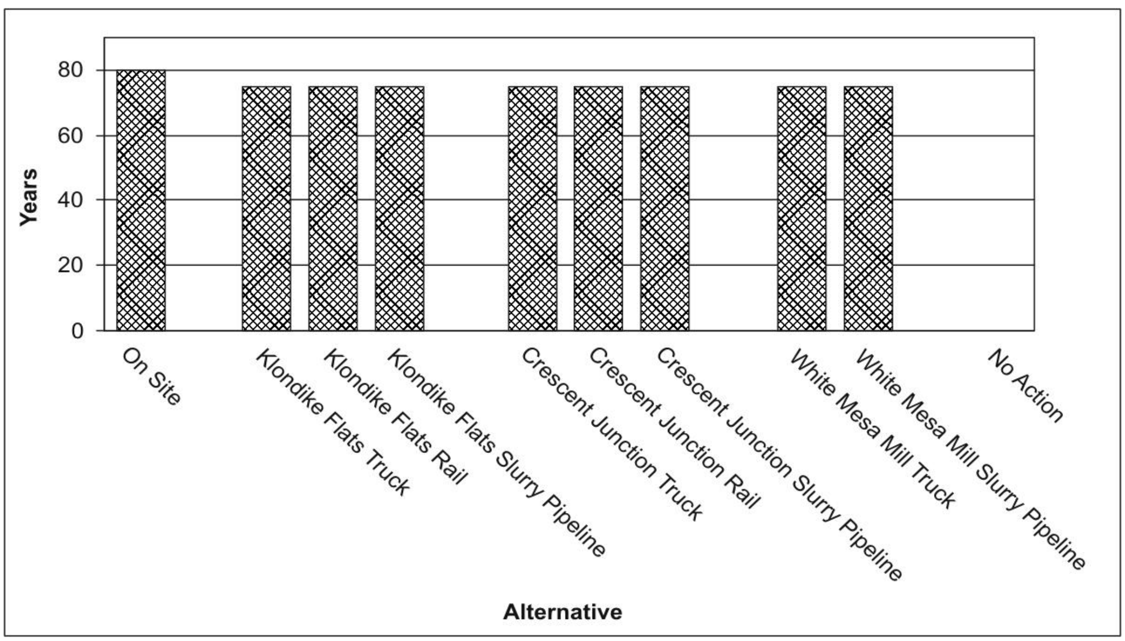


Figure 2–45. Estimated Duration of Ground Water Remediation

In the near term, DOE estimates that the proposed ground water remediation system would result in surface water quality that is protective of aquatic species in the Colorado River within 5 years after the system was implemented.

DOE also anticipates that contaminant concentrations in ground water and surface water that are protective of aquatic species in the Colorado River could be maintained, under all action alternatives, for the 200- to 1,000-year time frame specified in EPA's regulations (40 CFR 192.32[b][1][i]) promulgated under UMTRCA. However, under the on-site disposal and No Action alternatives, natural basin subsidence would result in permanent tailings contact with the ground water in 7,000 to 10,000 years, at which time surface water concentrations would temporarily revert to levels that are not protective of aquatic species in the Colorado River.

In addition, under the No Action alternative, the ground water beneath the Moab site would remain contaminated, would pose an increased risk to human health, and would continue in perpetuity to discharge contaminants to the surface water at concentrations that would not be protective of aquatic species. Cursory characterization indicates a potential for a salt layer in the upper zone of the tailings pile (see Table S–1). Modeling results indicate that under the on-site disposal alternative, contaminants from such a salt layer if present in the tailings pile would reach ground water in approximately 1,100 years and would affect ground water and surface water for approximately 440 years. Because ground water treatment would have been discontinued after an estimated 80 years, surface water concentrations could revert to nonprotective levels.

Surface Water. Under the No Action alternative, ground water and surface water contamination and nonprotective river water quality would continue in perpetuity. As stated in the discussion of ground water impacts, DOE estimates that under all action alternatives, contamination of the Colorado River from ground water discharge would be reduced to levels that would be protective of aquatic species within 5 years after implementation of ground water remediation because of the interception and containment of the contaminated ground water plume. Under the off-site disposal alternative, the removal of the pile coupled with the estimated 75 years of active ground water remediation would result in permanent protective surface water quality. Under the on-site disposal alternative, active ground water remediation would continue for an estimated 80 years.

In addition to natural subsidence described in the discussion of ground water impacts, a Colorado River 100- or 500-year flood could release additional contamination to ground water and surface water under the on-site disposal or No Action alternatives. However, under the on-site disposal alternative, the increase in ground water and river water ammonia concentrations due to floodwaters inundating the disposal cell would be minor, and the impact on river water quality would rapidly decline over a 20-year period. Under the No Action alternative, lesser flood events could also result in the release of contaminated soils to the Colorado River as sediment runoff. In contrast to the on-site disposal and No Action alternatives, the off-site disposal alternative presents no risk of these recurrences of surface water contamination at the Moab site because the tailings pile would be removed.

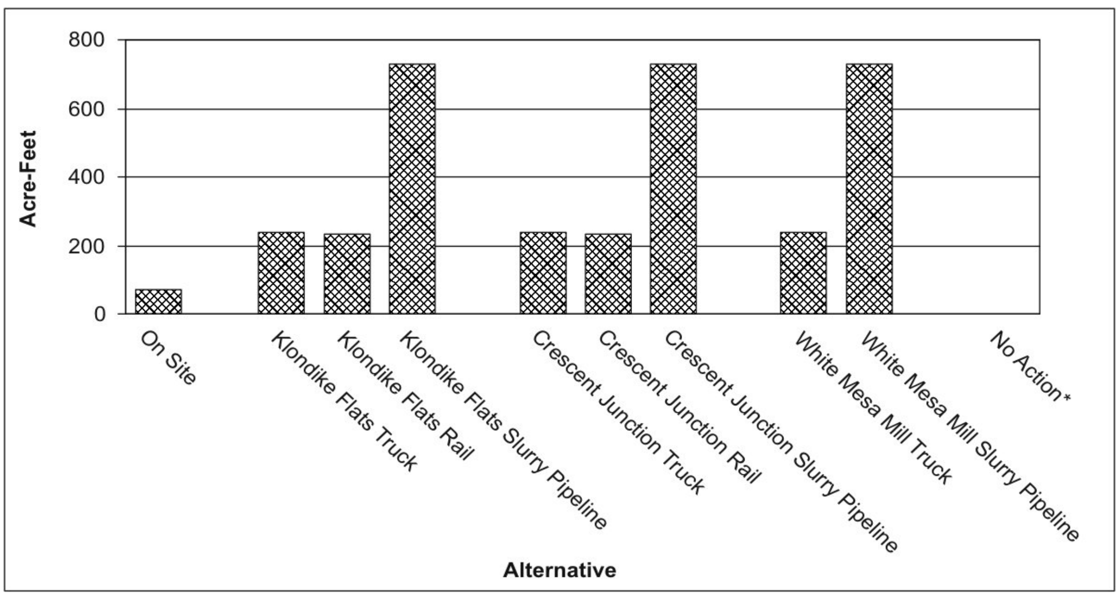
With the exception of ephemeral streams and impoundments, no surface water exists on or near any of the three off-site disposal locations.

Floodplains and Wetlands. As noted, 100- and 500-year flood events could partially inundate the disposal cell or pile under the on-site disposal alternative or No Action alternative. In addition, approximately 4.7 acres of wetlands could be contaminated in the long term under either of these alternatives. There are no known wetlands on or near the Klondike Flats or Crescent Junction sites, although potential wetlands exist near these sites and on the White Mesa Mill site. Under all the action alternatives, wetland areas on and adjacent to the Moab site could be adversely affected by surface remediation at the site, and for all action alternatives, activities would be necessary within the floodplain at the Moab site. Under the White Mesa Mill off-site disposal alternative, transportation of the tailings by slurry pipeline would require crossing the Colorado River, the Matheson Wetlands Preserve, and a number of perennial and intermittent streams. Potential wetlands near some borrow areas could be affected.

In accordance with its regulations (10 CFR 1022), DOE has prepared the *Floodplain and Wetlands Assessment and Floodplain Statement of Findings for Remedial Action at the Moab Site* and is included in the EIS as Appendix F.

Aquatic Ecology. Under the No Action alternative, the current adverse impacts to the Colorado River and to endangered aquatic species caused by contaminated ground water would continue in perpetuity. In comparison, under either the on-site or the off-site disposal alternative, these adverse impacts would cease within 5 years of the implementation of active ground water remediation, thereby eliminating the potential for impacts to aquatic organisms for the regulatory time frame of 200 to 1,000 years. Under the on-site disposal alternative and the No Action alternative, potential future releases of contaminants from natural subsidence (see the discussion of ground water) would cause adverse impacts to aquatic species in the Colorado River, but these impacts would not occur for at least 7,000 years. Under the off-site disposal alternative, the potential for future contamination from natural subsidence would be eliminated. Under all action alternatives, surface remediation activities at the Moab site would result in temporary disturbance to approximately 1.5 miles (8,100 ft) of Colorado River shoreline.

Annual withdrawals of Colorado River water (nonpotable water) are illustrated in Figure 2–46. All of these withdrawals are within DOE's authorized water rights. In addition, under the on-site disposal alternative, the required 70-acre-foot annual withdrawal would not exceed the 100-acre-foot annual limit that the USF&WS considers to be protective of aquatic species. However, this limit would be exceeded under the off-site disposal alternative.



*Impact would not occur under this alternative.

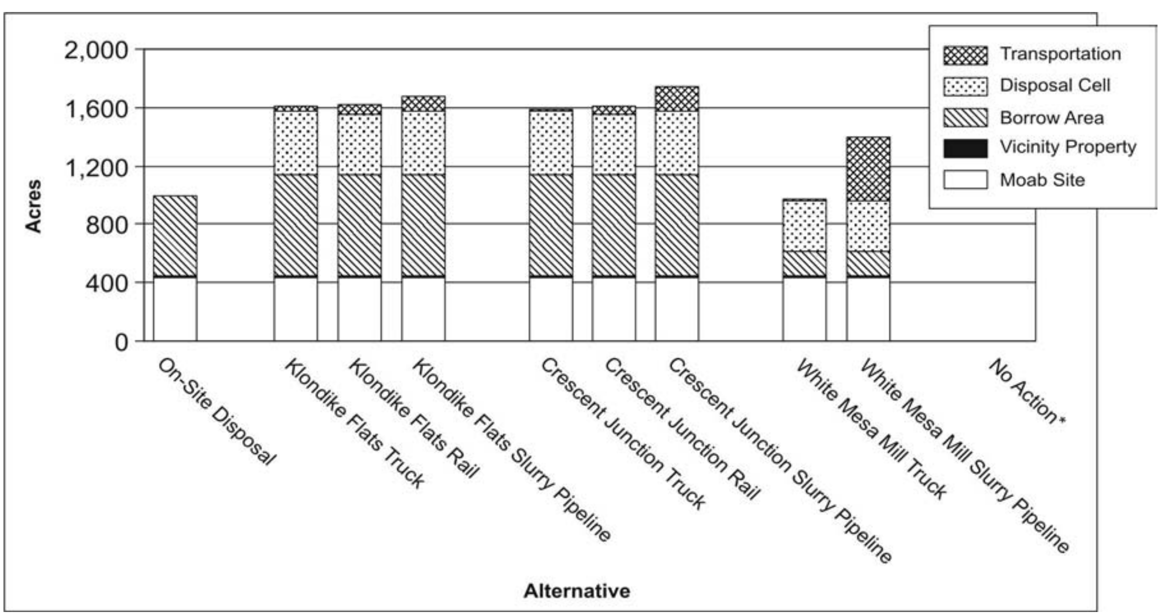
Figure 2–46. Annual Withdrawals of Colorado River Water

The truck or rail transportation modes would require annual withdrawals of 235 to 240 acre-feet, and the slurry pipeline mode would require annual withdrawals of up to 730 acre-feet, assuming all required slurry makeup and recycle water was drawn from the river. Exceeding the 100-acre-foot limit deemed protective for endangered fish species would be an unavoidable adverse impact. Mitigation would be accomplished in accordance with the cooperative agreement to implement the "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin." The recovery program requires that all Section 7 consultations address water depletion impacts, and a financial contribution (adjusted annually for inflation) be paid to USF&WS to offset the impacts of water depletion. The contribution collected by USF&WS would be used to fund activities necessary to recover the endangered fish as specified in the recovery plan.

Terrestrial Ecology. All action alternatives would result in the temporary loss of 50 acres of vegetation and habitat at the Moab site. This would also be an adverse impact to some aquatic species given the proximity of the Colorado River. For any of the action alternatives, effects of human presence could reduce the overall habitat value of the area and could adversely affect two to four threatened terrestrial species if they are present at the site. Impacts of physical disturbance could be avoided or minimized by conducting site-specific investigations prior to any development to determine the presence of any species of concern.

All action alternatives would produce short-term land disturbance to the entire Moab site, to vicinity properties, and to one or more borrow areas. Disposal at any of the three off-site locations would result in land disturbance associated with construction of the off-site disposal cell and the requisite transportation infrastructure.

In general, the vegetation that would be disturbed is sparse and provides only poor habitat for wildlife; however, under the White Mesa Mill slurry pipeline transportation option, much of the land disturbance would occur in previously undisturbed areas. Figure 2–47 depicts the total acres of disturbed land for all alternatives and the relative contribution to the total associated with five activities or facilities.



*Impact would not occur under this alternative.

Figure 2–47. Maximum Land Disturbance

Revegetation would minimize land disturbance impacts over the longer term. Under the No Action alternative, animal intrusion into the tailings pile could result in acute or chronic toxic effects to wildlife. Transportation of the tailings by truck to an off-site disposal location would result in an increase in wildlife traffic kills due to the increase in traffic.

Land Use. Under any of the disposal alternatives, the land dedicated to the disposal cell would be unavailable for any other uses in perpetuity. Under off-site disposal at the Klondike Flats and Crescent Junction locations, up to 435 acres of undisturbed BLM rangeland would be dedicated to the disposal cell and therefore would be permanently unavailable for grazing rights; although there are no known resources beneath the off-site locations, the potential for oil and gas and mineral extraction would be lost in perpetuity. Under off-site disposal at the White Mesa Mill location, up to 346 acres would be dedicated to the disposal cell and therefore would be permanently unavailable for any other uses. However, at the White Mesa Mill site, the land that would be dedicated to the disposal cell has already been committed to the disposal of radioactive material. Under the on-site disposal alternative, the entire 130-acre recontoured disposal cell would be permanently unavailable for any other uses.

Under either the on-site or any off-site disposal alternative, the land at the Moab site required for ground water remediation infrastructure would be unavailable for any other use for the 75 to 80 years needed to complete ground water remediation. If an evaporation ground water treatment technology were implemented, the evaporation ponds could require up to 40 acres, and support facilities would require additional land.

As mentioned, under the on-site disposal alternative, the entire 130-acre recontoured disposal cell would be permanently unavailable for any other uses. Under either the on-site or the off-site disposal alternative, DOE's goal would be to have as much of the 439-acre Moab site available for unrestricted use upon completion of surface remediation as would be possible. However, it is possible that even after completion of remediation, the entire 439-acre Moab site would remain under federal control permanently. Under any action alternative, final decisions on allowable future land use at the Moab site could be made only after the success of surface and ground water remediation was determined.

Cultural Resources. Only the Moab site and White Mesa Mill site have been field-surveyed; however, cultural resources would probably be adversely affected under all the action alternatives. The numbers of potentially affected cultural resources would vary significantly among the action alternatives (Figure 2–48). The on-site disposal alternative would have the least effect on cultural resources, potentially affecting 4 to 11 sites eligible for inclusion in the National Register of Historic Places. The White Mesa Mill slurry pipeline alternative would have the greatest adverse effect on cultural resources, potentially affecting up to 121 eligible cultural sites. The Klondike Flats alternative could adversely affect a maximum of 35 to 53 eligible sites (depending upon transportation mode), and the Crescent Junction alternative could adversely affect a maximum of 11 to 36 eligible sites (depending upon transportation mode).

A minimum of 10 to 11 traditional cultural properties would be potentially affected under the White Mesa Mill truck or slurry pipeline alternatives (Figure 2–49). (The term "traditional cultural properties" can include traditional cultural practices, ceremonies, and customs.) Mitigation of the potential impacts to cultural sites and traditional cultural properties under the White Mesa Mill alternative would be extremely difficult given the density and variety of these resources, the importance attached to them by tribal members, and the number of tribal entities that would be involved in consultations.

Noise and Vibration. Noise generated by construction and operations under any of the action alternatives would not exceed 65 A-weighted decibels (dBA) at any permanent receptor location. The 65 dBA level is the City of Moab's nighttime limit for residential areas. Remediation activities at vicinity properties under any of the action alternatives would cause temporary increases in local noise levels, and the City of Moab noise standard could be violated. Small vibrations from activities at the Moab site could be felt near the boundary of Arches National Park under any of the action alternatives. Under the Klondike Flats or Crescent Junction truck alternatives, truck noise could disturb temporary residents of Arches National Park seasonal housing complex. Under the Crescent Junction truck or rail alternative, residents of Crescent Junction at the intersection of I-70 and US-191 would likely be disturbed by the noise from trucks or trains passing through to the Crescent Junction site. Under the White Mesa Mill truck alternative, residents of Moab, La Sal Junction, Monticello, and Blanding would also probably be disturbed by the increase in truck noise.

Visual Resources. Under the on-site disposal alternative, adverse impacts to visual resources would occur during the short and long terms. Contrasts between the surrounding natural landscape and the newly constructed disposal cell would be strong and would attract the attention of casual observers. Although these contrasts would lessen slightly over time when the side slopes become vegetated, the disposal cell would continue to remain an anomalous feature in perpetuity. Under the No Action alternative, leaving the existing tailings pile in place would result in adverse visual impacts in perpetuity as well. The predominantly smooth, horizontal lines created by the tailings pile contrast moderately and would continue to contrast moderately with the adjacent vertical sandstone cliffs. Visual impacts under both of these alternatives would not be compatible with visual objectives assigned by BLM to nearby landscapes.

Visual Resource Contrast Rating

DOE rated the degree of contrast between natural landscapes and the proposed alternatives as follows:

None: the contrast is not visible or perceived.
Weak: the contrast can be seen but does not attract attention.
Moderate: the contrast begins to attract attention and begins to dominate the landscape.
Strong: the contrast demands attention, will not be overlooked, and is dominant in the landscape.

Implementation of the off-site disposal alternative would result in beneficial visual impacts at the Moab site because the pile would be removed and would have negligible to adverse visual impacts at the off-site disposal locations, depending upon viewing location. Disposal at the Klondike Flats site would have mostly negligible impacts over the long term, as the cell would not be visible to most observers. Disposal at the Crescent Junction site would have mostly negligible impacts over the long term, as the cell would create only weak contrasts with the surrounding landscape for most observers (those traveling I-70). One exception would be for travelers at the I-70 scenic overlook. The higher viewing angle at this elevated location would allow observers to view the top and side slopes of the cell. The simple, rectangular form of the cell would contrast strongly with the surrounding landscape during the short term, and moderately with the surrounding landscape in the long term. Disposal at the White Mesa Mill site would have mostly negligible impacts over the long term, as the cell would not be visible to most observers. The most adverse short-term impact to visual resources under the off-site disposal alternative would occur if the slurry pipeline transportation option were selected. The landscape scars created by the pipeline would be visible to travelers on US-191 and would create moderate contrasts in form, line, color, and texture with the surrounding landscape.

Infrastructure and Resource Requirements. Under all action alternatives, demand for electricity, potable and nonpotable water, and sewage treatment would not exceed local capacity or DOE’s withdrawal rights to Colorado River water. However, under the White Mesa Mill slurry pipeline transportation option, a booster pump station on the pipeline approximately 30 miles beyond the Moab site would be required. Powering the new pump station would require (1) adding a substation transformer at the Utah Power La Sal substation, (2) installing approximately 3 miles of new distribution line to service the booster pump station, and (3) upgrading the existing line from the La Sal substation to its current endpoint in Lisbon Valley. The required upgrade would entail modifications to line and pole configurations and capacities as necessary to accommodate the increased electric load represented by the booster pump station. A slurry pipeline to White Mesa Mill may also require a new substation transformer at Utah Power's Blanding substation and upgrades to the existing distribution line from the Blanding substation to the White Mesa Mill site. Exact upgrade requirements would be determined by the requisite detailed electrical engineering study if slurry pipeline transportation to White Mesa Mill were implemented.

Total diesel fuel consumption under the on-site disposal alternative would be 4 million to 5 million gallons. Total fuel consumption under the off-site disposal alternative would range from 12 million to 20 million gallons for truck transportation, from 10 million to 11 million gallons for rail transportation, and from 7 million to 9 million gallons for slurry pipeline transportation.

Weekly generation of sanitary sewage during surface remediation activities would range from 10,000 gallons (on-site disposal alternative) to 21,000 gallons (truck transportation option).

Figure 2–50 through Figure 2–54 compare the major resource and infrastructure requirements among the alternatives. These figures show that power and nonpotable water requirements would be significantly higher for the slurry pipeline alternative than for other alternatives. Fuel requirements for the White Mesa Mill truck alternative would be noticeably greater than for other alternatives because of the greater trucking distance. Sanitary waste generation would be greater for off-site disposal (15,000 to 21,000 gallons per week) than for on-site disposal (10,000 gallons per week), reflecting the larger work force and multiple work locations.

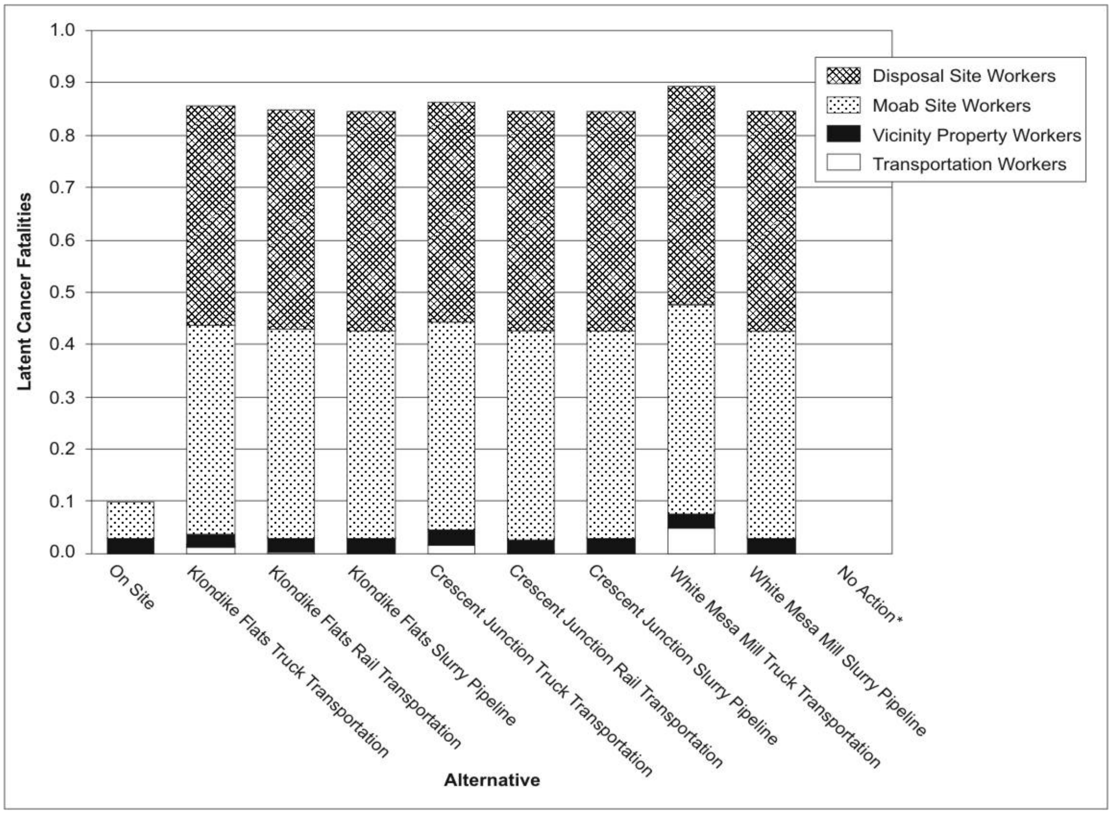
Waste Management. All action alternatives would generate identical amounts of RRM from treatment of contaminated ground water (Figure 2–55). Assuming ground water treatment would entail an evaporation technology, DOE estimates that this waste stream would consist of approximately 6,600 tons of RRM annually for 75 to 80 years and would be disposed of in the disposal cell or at another licensed facility. Surface remediation at the Moab site would generate approximately 1,040 yd^3 of solid waste annually under all action alternatives. Under any off-site disposal alternative, another 1,040 yd^3 of solid waste would be generated annually. These solid waste streams would be disposed of in the disposal cell or in local landfills. Landfills at Moab and Blanding could accommodate this volume of solid waste.

Socioeconomics. Figure 2–56 and Figure 2–57 compare socioeconomic costs and benefits (annual cost, output of goods and services, labor earnings, and job generation) among the alternatives. Of the action alternatives, on-site disposal would be the least expensive ($20.7 million annual average), assuming an 8-year period for surface remediation. The off-site disposal alternative would average between $41.3 million (Klondike Flats site) to $52.5 million (White Mesa Mill site) annually, using truck transportation. Rail transportation to Klondike Flats or Crescent Junction would average approximately $49 million annually. Slurry pipeline transportation would average between $49.4 million (Klondike Flats site) and $58.2 million (White Mesa Mill site) annually. The annual cost of each alternative would be directly proportional to the number of jobs that would be created regionally and the annual output of goods and services for each alternative.

The largest number of new direct and indirect jobs (778) would occur during the first year only of the White Mesa Mill pipeline alternative. For all pipeline alternatives, during the first year, the labor force would be higher due to pipeline construction; during years 2 through 8, the number of new jobs would be lower. On a sustained basis (years 2 through 8), the largest number of new direct and indirect jobs, 598, would occur under the White Mesa Mill truck transportation alternative (Figure 2–57). The smallest number of new direct and indirect jobs, 171, would occur under the on-site disposal alternative. Under both the on-site and off-site disposal alternatives, the increased work force would tend to cause some crowding-out impacts in hotels, apartments, and campgrounds in the Moab area during the peak tourism season, but lower vacancy rates would be expected during the off-season as workers took up temporary accommodation in the two-county region of influence. Crowding-out impacts would not be expected to occur in the White Mesa Mill area because of the availability of housing and accommodations.

The potential socioeconomic impacts from the No Action alternative would relate to potential longer-term damages that would result from leaving the pile and contaminated materials at vicinity properties where they are in their present form. These damages would include potential adverse impacts to human health, diminished quality of land and water resources, and potential losses in future economic development opportunities. In addition, implementation of the No Action alternative would result in loss of employment for the three to four individuals currently employed at the Moab site.

Human Health. No construction-related fatalities from industrial accidents are predicted to occur under any of the alternatives. However, construction and operations activities under all of the action alternatives would result in the exposure of workers and the public to very small amounts of radiation, which would present a risk of latent cancer fatalities among the workers and the public. Figure 2–58 shows total latent cancer fatalities for all workers by alternative and indicates the relative contribution to this impact for Moab site workers, disposal site workers, vicinity property workers, and transportation workers. The figure illustrates that latent cancer fatality risk to vicinity property and transportation workers would be very low compared to workers at the Moab site or at off-site locations. Site worker risk under the on-site disposal alternative would be less than half that under the off-site disposal alternative. Disposal at any of the three off-site locations would result in about 1 latent cancer fatality among the total worker population. The No Action alternative would result in no worker fatalities.



*Impact would not occur under this alternative.

Figure 2–58. Latent Cancer Fatalities Among Workers

Figure 2–59 illustrates the latent cancer fatalities predicted for members of the public from exposure to all sources of project-related radiation except for exposure to radiation at vicinity properties, which is presented in Figure 2–60. Estimates of latent cancer fatalities shown for the action alternatives in Figure 2–59 assume public exposure during the course of remediation activities and for 30 years thereafter. Approximately 1 latent cancer fatality would occur under the off-site disposal alternative from exposure to radiation (excluding exposures to vicinity property material), and this fatality would be almost entirely associated with exposure to radiation from remediation activities at the Moab site as opposed to off-site locations (Figure 2–59). Among the three transportation modes, the slurry pipeline mode represents the lowest public risk (0.75 latent cancer fatality) compared to 1.0 latent cancer fatality for truck or rail transportation. In contrast, the on-site disposal alternative represents a risk of about one-quarter of a latent cancer fatality among the public, and the No Action alternative represents just over 5 latent cancer fatalities among the public over a 30-year time period.

Figure 2–60 illustrates the potential latent cancer fatalities among members of the public due to exposure to radiation at vicinity properties based on the conservative assumptions used for analyses. For the action alternatives, this figure shows the relative contribution to the aggregate risk for 5 years before and for 30 years after remediation. DOE estimates that there would potentially be 12 latent cancer fatalities among the public under any action alternative and 26 latent cancer fatalities if the No Action alternative were implemented. These risks reflect ongoing long-term exposure dating back to the beginning of mill operations.

The design life of the disposal cell for the uranium mill tailings is 200 to 1,000 years. Over this period of time, the amount of radioactivity in the disposal cell will decrease slightly, less than 1 percent, due to the decay of the radionuclides in the uranium mill tailings. In the time frame of 200 to 1,000 years, the major route of exposure of people would be through the inhalation of radon progeny from the disposal cell. Even though DOE's experience supports a conclusion that radon release rates from the capped pile would be negligible, and DOE's long-term monitoring and maintenance of the site would ensure cap integrity, for the purpose of supporting analyses of long-term performance and impacts, DOE has also assessed impacts assuming the maximum allowable release rate of radon, 20 picocuries per square meter per second (pCi/m^2-s), under EPA's regulations (40 CFR 192).

On the basis of this emission rate, after the disposal cell cover was installed the annual latent cancer fatality risk from radon for a nearby resident at any of the disposal sites is estimated to be 8.9×10^{-5} per year of exposure. As with the radioactivity in the disposal cell, the annual risk would also not decrease appreciably over the 200- to 1,000-year time. Therefore, the annual latent cancer fatality risk for a nearby resident would be about the same immediately after the cover was installed as it would be 1,000 years after the cover was installed.

Long-term population risk assessment for this 1,000-year period would be greatly influenced by changing demographics. For comparison among the on-site and off-site alternatives, assuming no changes in population numbers or geographic distribution yields the following population risks over 1,000 years: the population around the Moab site would incur 6 latent cancer fatalities; the population around the Klondike Flats site would have a latent cancer fatality risk of 0.09; the population around the Crescent Junction site would have a latent cancer fatality risk of 0.07; and the population around the White Mesa Mill site would have a latent cancer fatality risk of 0.1.

Release of uranium mill tailings in a truck or rail transportation accident would not be expected to result in any latent cancer fatalities to either the exposed population or the maximally exposed individual.

Figure 2–61 compares nonradiological fatalities predicted among members of the public due to project-related traffic accidents and to exposure to project-related nonradiological pollutants during surface remediation activities. There would be less than one-tenth of one fatality due to exposure to nonradiological pollutants (for example, exhaust emissions) under any action alternative (Figure 2–61). Traffic fatalities would be directly proportional to truck shipment miles; fewer than one traffic fatality is predicted to occur under any action alternative except the White Mesa Mill truck alternative, where 1.3 traffic fatalities are predicted.

Traffic. Figure 2–62 through Figure 2–64 depict traffic impacts among the alternatives. All the proposed action alternatives would result in increased traffic on local roads and US-191. Among the three off-site disposal locations, truck transportation to the White Mesa Mill site would represent the most severe impact to traffic in central Moab, an area that UDOT currently considers to be highly congested. Transportation of contaminated materials from the Moab site to the White Mesa Mill site would result in a 127-percent increase in average annual daily truck traffic through Moab. In contrast, if the tailings were trucked to the Klondike Flats or Crescent Junction sites, or if either the rail or slurry pipeline transportation modes were implemented for any of the off-site disposal locations, there would be only a 7-percent increase in truck traffic through central Moab from shipments of vicinity property materials under all action alternatives, and only a 2- to 3-percent increase from shipments of borrow materials for the on-site disposal alternative or for off-site disposal at the Klondike Flats or Crescent Junction locations. All alternatives would also result in an overall increase in the average annual daily truck traffic on US-191, both north and south of Moab, from shipments of contaminated materials and borrow materials. These impacts would be most severe with the off-site truck transportation mode, which would increase average annual daily truck traffic on US-191 by 95 percent for the Klondike Flats or the Crescent Junction alternative and by 65 to 186 percent for the White Mesa Mill alternative, depending on the segment of US-191.

In comparison, the on-site disposal alternative and the rail or pipeline off-site alternatives would increase average annual daily truck traffic on US-191 only by 7 percent. Assuming conservatively that each worker would commute through Moab, the increase in all traffic through central Moab due to commuting workers would be minor for all alternatives, ranging from a 1- to 5-percent increase. As shown in Figure 2–61, DOE estimates that less than one traffic fatality would occur for all alternatives and transportation modes with the exception of truck transportation to White Mesa Mill, for which modeling predicts that 1.3 traffic fatalities would occur.

Environmental Justice. Disproportionately high and adverse impacts to minority and low-income populations would occur under the White Mesa Mill off-site disposal alternative (truck or slurry pipeline transportation) as a result of unavoidable adverse impacts to at least 10 to 11 potential traditional cultural properties located on and near the White Mesa Mill site, the proposed White Mesa Mill pipeline route, the White Mesa Mill borrow area, and the Blanding borrow area. Moreover, if the White Mesa Mill alternative were implemented, it is likely that additional traditional cultural properties would be located and identified during cultural studies. DOE would address the potential for adverse impacts to these properties once they were discovered.

The sacred, religious, and ceremonial sites already identified as traditional cultural properties are associated with the Ute, Navajo, and Hopi cultures and people. Currently, there are no known traditional cultural properties at any other site, although the potential for their being identified during cultural studies and consultations ranges from low to high, depending on the site and mode of transportation. The impacts to all other resource areas analyzed in the EIS (for example, transportation or human health) would not represent a disproportionate adverse impact to minority and low-income populations under any alternative.

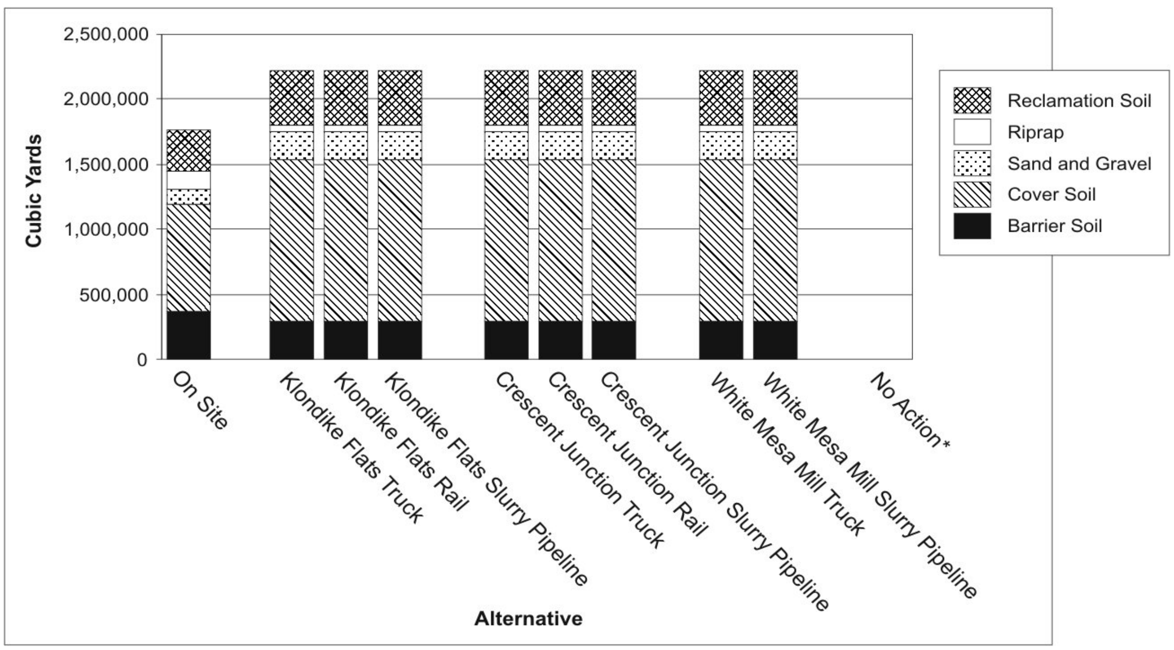
Disposal Cell or Tailings Pile Failure. Under the on-site remediation alternative and No Action alternative, a disposal cell or tailings pile failure could pose a risk under the residential scenario and could result in adverse impacts to aquatic receptors from uranium and ammonia concentrations in the Colorado River. The risk would be much lower for the off-site disposal locations because the sites are not located near a river, do not have historical seismic activity, are not prone to subsidence attributed to salt dissolution below the alluvial basin, and are located away from population centers and sensitive habitats. The possibility and consequences of a tailings pile failure are greatest under the No Action alternative because it would not include the use of engineering controls to mitigate impacts from floods and other natural events as would occur under the on-site disposal alternative.

Table 2–32 compares the impacts analyzed in the EIS. In general, the information in Table 2–32 is the same as that provided in this section. The information is repeated in tabular form as an aid to readers who may wish to rapidly compare a specific impact across all alternatives.

2.6.2 Impacts Affecting Potential Borrow Areas

Although impacts to borrow areas would occur under any of the alternative actions, these impacts are discussed separately in this section in response to a request by BLM, one of the cooperating agencies. BLM indicated that analyzing impacts to borrow areas as a stand-alone topic would facilitate subsequent analyses necessary to authorize DOE to use borrow material at BLM-managed borrow areas.

All of the off-site disposal locations would require approximately the same amount of borrow material (2.2 million yd^3), about 20 percent more than the 1.8 million yd^3 that would be needed for the on-site alternative (Figure 2–65). The relative amounts of the five types of borrow material would be very similar for all alternatives, and approximately 90 percent of the required borrow material would be excavated soil (Figure 2–65). Further description of impacts at borrow areas is provided in Section 4.5 and Table 4−52.



*Impact would not occur under this alternative.

Figure 2–65. Borrow Material Requirements

2.6.3 Consequences of Uncertainty

The purpose of this EIS is to assess and compare the potential environmental impacts associated with reasonable alternative actions to remediate the uranium mill tailings pile at Moab and contaminated ground water beneath the site. The EIS describes these impacts as accurately as possible given the available data and certain assumptions as required in the Council on Environmental Quality's NEPA regulations (40 CFR 1502.22). However, DOE recognizes that uncertainties are associated with these assumptions and that some of the assumptions could turn out to be inaccurate. Other areas of uncertainty have developed between DOE and one or more of its cooperating agencies on issues regarding regulatory or scientific interpretation. These uncertainties are relevant to decision-making, because if any of the assumptions underlying the EIS change significantly, the impacts as described could also change. It is important that decision-makers are cognizant not only of the nature and range of uncertainties inherent in the EIS but also of the potential consequences of these uncertainties. Many of the uncertainties have been identified and acknowledged in the EIS. This section delineates the major uncertainties and, to the extent possible, describes the potential consequences of them.

The uncertainties in the EIS include areas as diverse as the future regulatory environment, the duration of worker exposure to radiation, ground water modeling assumptions, and the timing of congressional appropriations. Some of these uncertainties (for example, congressional appropriations) would be "alternative neutral" in that the consequence of the uncertainty would be expected to affect all alternatives in the same way and to the same degree, with the exception of the No Action alternative. Other uncertainties would be irrelevant to some alternatives but of significant potential consequence to others. For example, the uncertainties surrounding the speed and direction of river migration are relevant to the on-site or No Action alternatives but are of no consequence to the off-site disposal alternative because the pile would have been removed.

The majority of these uncertainties relate to the intrinsic variability and heterogeneity of the natural media to which DOE is applying engineering solutions. The types and degrees of uncertainty identified in this section are typical of those that have been encountered during the characterization and remediation of the previous 22 sites designated under Title I of UMTRCA and are similarly typical of the uncertainties associated with this stage of decision-making for remedial action projects. Based on DOE's extensive history with the remediation of uranium mill tailings sites, reasonable conservatism has been employed in characterizing the costs, resources, and impacts associated with meeting the statutory requirements of UMTRCA and NEPA. Consistent with the Council on Environmental Quality requirements for incomplete or unavailable information (40 CFR 1502.22), within this EIS DOE has explicitly identified its assumptions where information may be limited, clearly indicated the methods and models used in its analyses, and evaluated the potential relevance of incomplete or unavailable information to decision-making.

Table 2–33 identifies the major areas of uncertainty, characterizes the changes that might occur in the predicted impacts, and establishes the relative effect that such changes in impacts might have on the alternatives evaluated in this EIS.

2.6.4 Responsible Opposing Views

As a result of input developed in the public comment process and consultations with the 12 cooperating agencies, DOE has identified three general topics on which there exist responsible opposing views to DOE's position regarding the remediation alternatives for the Moab site: river migration, contaminated ground water flow under the river to the Matheson Wetlands Preserve, and the appropriate compliance standard for aquatic species in the river. Sections 2.6.4.1 through 2.6.4.3 summarize the responsible opposing views on these topics, DOE's positions on these topics, and the implications for the alternatives should DOE's views prove to be incorrect.

2.6.4.1 Responsible Opposing Views on River Migration

Several commentors, including state and federal agencies, presented their views regarding the EIS's characterization that the dominant direction of river migration over the next 200 to 1,000 years will be away from the site and that, should the tailings and associated wastes be remediated on the site, the infrastructure proposed under this alternative could be built and maintained in a manner protective of public safety and the environment. Specifically, commentors based their views on different interpretations of data addressed in the EIS.

- *USGS Study*. In a recent study (USGS 2005), the USGS used a multidimensional hydrodynamic model to explore the hydraulic conditions of the existing channel geometry and three hypothetical channel scouring geometries under 100-year (97,600 cfs), 500-year (120,000 cfs), and PMF (300,000 cfs) discharge conditions. Water surface elevations, velocity distributions, and shear-stress distributions were predicted for each discharge and each channel geometry. The report states that "...predicted main-channel bed stress values indicate substantial transport of medium-sized gravels for the simulations conducted with the existing channel geometry. Transport of coarse sands was predicted near the tailings for the 100-year discharge, and fine gravel transport was predicted in this region for the PMF discharge." Overbank shear stresses are greatest for the hypothetical 25-ft scour channel geometry. The State of Utah and others have interpreted the results of this study to indicate that substantial potential for erosion of the riverbank adjacent to the tailings pile exists and that this potential poses a sufficient threat and uncertainty to warrant relocation of the tailings to a more geologically stable location.
- *Interpretation of Historical Documents*. Dr. John Dohrenwend questioned DOE's interpretation of the 80-year history documented by historical maps and aerial photographs. A particular concern was that the photographs were not properly registered or interpreted. Dr. Dohrenwend's interpretation was that if the images were properly registered or evaluated, they would show that the Colorado River is not migrating south and east away from the tailings pile, but rather to the north and west, toward the pile. Comment 429 in EIS Volume III, "Comment Responses," presents the complete text of Dr. Dohrenwend's opposing view.
- *Significance of Flows into the River*. Dr. John Dohrenwend raised the issue of the significance of Courthouse Wash and Moab Wash on the movement of the Colorado River. Dr. Dohrenwend and others suggested that flows from Courthouse Wash have deposited sediments on the south side of the Colorado River channel and, therefore, have actively contributed to the northward migration of the river channel, not southward and eastward as indicated in the EIS.

- *Interpretation of Data*. DOE's interpretation of available well log and borehole data was called into question. Dr. John Dohrenwend and the State of Utah interpreted the available data to indicate that the valley fill is not thickest and deepest south of the present location of the river channel, but rather beneath or perhaps as much as several hundred feet north of the present river channel. Therefore, the commentors maintained, there is no reason to suppose that continuing subsidence of the valley floor would cause the river channel to migrate away from the tailings pile. The opposing interpretation is that if the thickest and deepest valley fill deposits mark the position of maximum valley subsidence, there would instead be strong reason to suppose that continuing subsidence could cause the river to move closer to the pile.

  Dr. Dohrenwend also challenged DOE's interpretation of available subsurface data. He interpreted these data to show that conditions directly beneath the tailings pile are much more complex than presented in the EIS. The opposing interpretation is that the data indicate localized subsidence of the valley floor and that the subsidence must be considered as a possible and potentially serious geologic hazard. Moreover, a comparison of surface and subsurface data along the northern margin of Moab Valley between Courthouse Wash and the millsite suggests the possibility that localized subsidence or extremely deep channel scour has occurred in this area sometime during the past 45,000 years.

- *Dissolution of Salt Layers*. Dr. John Dohrenwend raised the issue of the dissolution of the salt layers (Paradox Formation) beneath Moab Valley. Dr. Dohrenwend maintains that dissolution of the salt layers is causing slow subsidence of the alluvial fill within the valley. In his interpretation, the Colorado River and its local tributaries deliver far more sediment to the valley floor than could ever be accommodated by the valley's slow subsidence. Therefore, ongoing deposition by the Colorado River and by Mill Creek and Pack Creek are the principal processes controlling the surficial geology and geomorphology of Moab Valley.

Commentors agreed with the EIS characterization that the geometry and position of ancient Colorado River gravels buried beneath the surface of Moab Valley clearly show that the Colorado River has shifted back and forth across the mill and tailings site in the recent geologic past. However, they interpret these data to mean that the river is therefore likely to traverse the site again in the near future.

The issue of recent flooding in the St. George and Santa Clara regions of Utah was also presented. The commentors interpreted these recent flood events on other drainages in Utah as demonstrations of the swift and immense force of floodwater in the desert. Some commentors have indicated that the unanticipated results of these occurrences demonstrate mankind's inability to adequately predict or engineer and plan for such impacts and that this potential poses a sufficient threat and uncertainty to warrant relocation of the tailings to a more geologically stable location.

In summary, commentors suggested that scientific evidence exists indicating flaws in DOE's interpretation concerning the suitability of the Moab millsite for the long-term disposal of the uranium mill tailings and associated waste. They maintain that the Colorado River channel has migrated both toward and away from the Moab millsite in the past 80 years and that it could do so in the future. The overall concern expressed by commentors is that the EIS has mischaracterized the available data and that the dynamic and often unpredictable nature of the river system and the inevitable migration of the river toward the site over geologic time make on-site disposal an inappropriate alternative. Their view is that under this alternative the potential impacts of river migration would pose unacceptable risks to a multitude of local and downstream users, as well as the ecological receptors of the Colorado River corridor.

DOE's Position on River Migration

DOE's position concerning lateral migration potential of the Colorado River is stated in a 2003 river migration report (DOE 2003a): "Although a conclusive prediction of future river movement is not possible, evidence suggests that the river is and will continue migrating to the south and east away from the existing tailings pile." The basis for this claim is supported by the following technical arguments:

- Historical evidence of river migration (e.g., aerial photographs, historical topographic and property survey maps) indicates that the river has remained stable to moderately stable for the last 120 years, suggesting that catastrophic rapid channel migration is unlikely and indicating that all floods have dissipated by overflow into the Matheson Wetlands Preserve. Significant movement of the right bank (tailings side) has not occurred in the historical time frame.

- Sediment input from Courthouse Wash and Moab Wash has created an alluvial fan upon which the tailings impoundment is constructed. Both washes have delivered significant quantities of sediment in the past and will continue to do so into the future unless profound changes occur in the watersheds. Sediment deposition has pushed the river channel south into Moab Valley.

- The current location of the Colorado River is approximately 1,100 ft south of the terrace formed at the confluence of Courthouse Wash and the Colorado River, suggesting that the river has moved south since the time the terrace gravels were deposited. Geologic mapping by the Utah Geologic Survey has dated this terrace as late Pleistocene, and this date is supported by correlation of soil profiles. The terrace age provides an indication of the length of time in the past the river channel was at that location and was flowing with a velocity high enough to transport and erode gravels. This finding indicates that the right riverbank has been stable for the last 30,000 years.

- The thickness and distribution of basin-fill sediments in Moab Valley indicate past and continuing salt dissolution of the valley. Subsidence creates a zone of accommodation for alluvial fill material transported by the Colorado River.

- The rate and character of salt dissolution in the Moab Valley area indicate that significant dissolution has occurred in the past and has trapped large quantities of sediment.

The absence of a cobble-gravel bedload downstream of the Portal (the location where the river exits Moab Valley and enters a canyon) suggests current salt dissolution of Moab Valley. Ongoing dissolution will tend to control the position of the Colorado River, and based on geologic evidence, subsidence is occurring beneath the Matheson Wetlands Preserve.

Implications of Opposing Views on River Migration

If the river migrates gradually to the north and west toward the disposal cell, annual inspections would afford the long-term steward, required under UMTRCA, the opportunity to implement additional mitigation measures beyond the disposal cell riprap side slopes and engineered buried riprap barrier wall already included in the conceptual design to ensure long-term protection. This could potentially involve additional bank armoring and stabilization and enhancement of the disposal cell riprap side slopes and engineered buried riprap wall. These efforts could involve additional temporary impacts at riprap borrow sources, temporary disturbances in the floodplain and riverbank areas associated with implementation of these enhancements, and additional transportation impacts associated with transporting the riprap or stabilization materials to the site. The cost of these measures could run to several million dollars.

The impacts to public health and the environment, should the river migrate toward the disposal cell catastrophically, is addressed in Section 4.1.17 of the EIS.

2.6.4.2 Responsible Opposing Views on Contaminant Flow Under the River

Dr. Kip Solomon and Phil Gardner of the University of Utah and commentors from the State of Utah, which commissioned Dr. Solomon's study, opposed DOE's view regarding the fate and transport of site-derived contaminants in ground water. This view states that these contaminants have migrated, and continue to migrate, under the Colorado River toward the Matheson Wetlands Preserve and that they pose a potential hazard to public health and the environment. This view is based primarily on the interpretation of three types of information: (1) a ground water flow gradient map based on calculated hydraulic heads that account for the effects of salinity on flow potential, (2) measured uranium concentrations in ground water on both sides of the Colorado River, and (3) analysis of stable isotopes of dissolved oxygen and hydrogen in ground water.

Values of equivalent freshwater head (EFH) were calculated by Gardner and Solomon (2003) at nine wells screened in brine at a common elevation of 3,904 ft above mean sea level. The calculations were performed using measured water levels at the wells and estimated TDS concentrations in the well columns at the common elevation. The resulting EFH values were plotted on a map of the area and contoured using a 1.6-ft contour interval. Contours of equal potential indicated ground water movement to the south-southeast; Gardner and Solomon infer that ground water on the project side of the river has the capacity to flow under the river toward the Matheson Wetlands Preserve. They also concluded that the sub-riverbed flow occurs within highly permeable basin fill consisting of very coarse sands and gravels, which are commonly observed on both sides of the river at a depth of about 16 to 23 ft below ground surface.

A map of posted uranium concentrations in ground water at five wells on the project side of the river and 14 wells southeast of the river (Gardner and Solomon 2003) suggested that uranium concentrations in wells along the river's east bank and in and near the Matheson Wetlands Preserve were derived from contaminated ground water on the Moab site. The explanation given for this connection was that ground water flows below the riverbed from the project site to the wetlands area in the very coarse basin fill sediments found in both areas. The study presented two cross-sections showing measured uranium levels in selected monitor wells on either side of the river as support for the possible transport of uranium from one area to the other.

Two cross-sections by Gardner and Solomon (2003) containing measured oxygen isotope ($\delta^{18}O$) ratios did not conform to DOE's conceptual model of ground water flow at the Colorado River, which hypothesizes that the river itself or an area close to its east bank acts as a ground water divide. Such a divide would likely result in more negative $\delta^{18}O$ ratios (compared to standard mean ocean water ratios) with depth in the ground water system near the river. However, Gardner and Solomon pointed out that less negative $\delta^{18}O$ ratios are observed below more negative ratios just to the southeast of the river. From this observation, the authors concluded that ground water from the project site with less negative $\delta^{18}O$ ratios migrates to deeper ground water below the Matheson Wetlands Preserve.

The Gardner and Solomon study also used dissolved ammonia concentrations on either side of the Colorado River as additional evidence to support a sub-riverbed hydraulic connection between the project site and the wetlands. Tailings-related, high ammonia contamination on the site is obvious, and the authors suggest that slightly elevated ammonia concentrations in ground water on the east side of the river are probably caused by subsurface transport from the site.

DOE's Position on Contaminant Flow Under the River

DOE's conceptual model of ground water flow at and near the project site considers the Colorado River and a limited area located just to the southeast of the river to be a site of both regional and local discharge for subsurface water. Ground water discharges to this area because the elevation of the river surface and shallow ground water to the immediate southeast is less than the flow potentials measured in ground water at the project site, in areas lying farther to the east and closer to the city of Moab, and in brine located beneath the river. Ground water flow converges toward the river from all of these zones, and a ground water divide occurs either in the river itself or slightly east of the river. This flow pattern prevents water from migrating beneath the river to the Matheson Wetlands Preserve.

The unique salinity conditions observed in ground water in the study area are attributed to the river's natural tendency to act as a site of regional discharge. Very saline water to brine is observed on both banks of the river at about the elevation of the riverbed. DOE views this phenomenon as a form of saltwater upconing that is similar to the upconing that would occur below a well that withdraws relatively fresh ground water above a saline zone. A natural source for the brine in the Moab study area is the dissolution of evaporite sediments that make up the Paradox Formation, which appears to subcrop hundreds of feet below the riverbed.

Information supporting this conceptual model includes flow potential data on both sides of and near the river. A significant upward component of flow was observed in these types of data collected at the project site for the SOWP (DOE 2003b). Steep upward gradients are also indicated in the data collected from three deep boreholes drilled just east of the river for the Gardner and Solomon (2003) study. From prominent studies of regional ground water flow over brine sources, it can be deduced that such upward gradients are expected in the vicinity of a site of ground water discharge. These studies also demonstrate that ground water velocities in the brine are very small and explain how relatively fast-moving fresh water above the brine moves mostly laterally to the site of discharge (e.g., a river). In effect, the brine at the discharge site acts as a barrier to ground water flow, thus limiting flow from one of its sides to the other. In a similar manner, DOE's conceptual model of ground water flow envisions shallow water converging toward the Colorado River from both the northwest and southeast and postulates that brine does not flow below the river from one side to the other.

From the available data and corresponding flow assessments, DOE concludes that ground water contamination does not migrate under the river from the project site to the Matheson Wetlands Preserve. The occurrence of ammonia (as nitrogen) concentrations in the 3- to 5-mg/L range measured just to the southeast of the river can be explained by the natural upconing of briny water in the vicinity of the river, not the result of sub-riverbed flow. Accordingly, DOE believes that the project site poses no potential human health risk on the east side of the river and that the site does not affect ecological receptors east of the river.

A review of measured ammonia concentrations in wells located close to the river but on its east side indicates that these ammonia levels have a high probability of being naturally caused. Ammonia levels in wells screened within uncontaminated brine near the river are typically in the 3- to 4.5-mg/L range, which is the same range observed in ground water on the river's east side. In addition, oil and gas wells drilled into the Paradox Formation in the vicinity of Moab Valley have encountered brine with ammonia concentrations as high as 1,330 mg/L.

<u>Implications of Opposing Views on Contaminant Flow Under the River</u>

If significant contaminant mass has flowed and continues to flow beneath the river eastward toward the Matheson Wetlands Preserve, contaminant concentrations would increase in the ground water in these areas. The existing concentrations of ammonia, uranium, sulfate, and chloride on the east side of the river are all within the range of natural background. It is not clear that future contaminant migration to the east side of the river would cause a significant health risk to the public or the environment. Because of the naturally high concentrations of TDS, chloride, and sulfate in all but the shallowest waters on the east side of the river (TDS below 3 to 14 feet is between 40,000 and 124,000 mg/L), the incremental addition of contaminants from the Moab site would not reasonably result in a significant increase in risk to receptors, given the poor ambient water quality and lack of exposure pathway. However, in the extreme case, additional ground water remedial action could be required to address the deeper contamination on both sides of the river. This could involve installing additional ground water monitor and extraction wells and implementing additional ground water treatment capabilities for many decades. Should this be required, implementation of these measures could cause (1) additional temporary surface disturbance on the tailings side and on the east side of the river within the floodplain, (2) additional water treatment waste generation for decades, and (3) the consumption of additional utilities. Consumption of water in the treatment process may have depletion impacts on recharge to the river commensurate with the extraction and treatment requirements of the system.

However, the current water quality of all but the upper few feet of the several-hundred-foot-thick aquifer on the east side of the river, like that on the west (tailings) side of the river, is an order of magnitude worse than any potential use criteria (more than 80,000 mg/L TDS—more than twice the salinity of sea water). Due to the naturally high salinity of the ground water on the east side of the river it is not used for drinking water, irrigation, or livestock watering. Therefore, there is no limited use of the aquifer on the east side of the river.

2.6.4.3 Responsible Opposing Views on the Appropriate Compliance Standard

The State of Utah and others presented opposing views regarding DOE's target cleanup goal for ground water of 3 mg/L ammonia (as nitrogen). The opposing view is that the ground water cleanup goal for ammonia should be the chronic AWQC for ammonia rather than the acute standard. These criteria vary depending on pH and temperature, but a value of 0.6 mg/L was shown in the SOWP (DOE 2003b) to be applicable for the vast majority of surface water conditions. The commentors maintain that the 0.6-mg/L ammonia goal must be met in ground water to ensure that it can also be met in quiet backwater areas that serve as endangered fish habitat. Their interpretation disagrees with DOE's interpretation that ground water discharging to the surface will undergo dilution by a factor of 10 or more. The high standard deviation associated with the average dilution factor is cited as evidence that there is no statistical basis for DOE's assumed dilution factor. Their view contends that DOE's analysis was based on data collected for purposes other than estimation of a dilution factor and that a much more rigorous sampling is required before a defensible dilution factor can be established. Commentors further argued that unless DOE better understands the geochemical behavior of ammonia as it is transferred from ground water to surface water, DOE has no choice but to apply the 0.6-mg/L criterion as a conservative interim cleanup goal.

Finally, the State of Utah questions DOE's conclusion that only 80 years of active ground water remediation would be required to meet remediation goals. This view is predicated on doubts that DOE's application of a 3-mg/L ammonia cleanup goal would be protective because of dilution of ground water as it discharges to the surface. The opposing view indicates that at least 200 years would be required to achieve the 0.6-mg/L level based on DOE's contaminant transport model. Also, the State of Utah maintains that the State can enforce the appropriate protective criteria in ground water.

<u>DOE's Position on the Appropriate Compliance Standard</u>

DOE has established the target cleanup goal for ammonia in ground water based on the national AWQC, considerable study of ground water and surface water data, and direct consultation with the USF&WS. These data were collected expressly to determine the validity of the conceptual site model presented in the SOWP and to better understand ground water-surface water interactions and the effect of discharge of ground water to the Colorado River. Results of these evaluations were presented in the SOWP (DOE 2003b), the *Fall 2004 Performance Assessment of the Ground Water Interim Action Well Fields* (DOE 2005a), the *Ground Water/Surface Water Interaction for the Moab, Utah, Site* (DOE 2005b), and the *Performance of the Ground Water Interim Action Injection System at the Configuration 2 Well Field* (DOE 2005c). Also, the USF&WS has since prepared a Biological Opinion, which concurs that the target cleanup goal for ammonia in ground water is reasonable. In its Biological Opinion, the USF&WS indicates that additional studies are required as a reasonable and prudent measure to increase confidence for this target goal.

Specifically, DOE's use of the 3.0-mg/L acute ammonia-nitrogen standard as a ground water cleanup goal is based on the national AWQC. The acute criterion is a function of water pH, and the chronic criterion is a function of water temperature and pH. The national criteria documentation does not recommend using an average temperature and pH to calculate a single applicable value for the standards, but rather a range of standards that may apply under observed pH and temperature conditions. Chronic aquatic criteria represent the low end of the potential concentration range for protection of aquatic species from ammonia toxicity. The majority of chronic values measured in the surface water at the Moab site range from 0.6 to 1.2 mg/L ammonia (total as N) based on site-specific pH conditions. Acute criteria represent the higher end of the concentration range; the majority of acute values measured in the surface water range from 3 to 6 mg/L based on site-specific temperature and pH conditions. Therefore, it is DOE's position that ammonia concentrations (total as N) in surface water in the 0.6- to 6-mg/L range would be fully protective of aquatic life.

As discussed in Section 2.3.1.2, if ammonia concentrations in the ground water met the surface water standards, then discharge of ground water to the surface should not result in exceedances of those standards unless some other process (e.g., evaporation) increased contaminant concentrations in surface water. However, establishing the lowest end of the protective range as the ground water cleanup goal is not considered necessary to achieve compliance with surface water standards. Available data regarding interaction of ground water and surface water indicate that concentrations of constituents generally decrease significantly as ground water discharges to and mixes with surface water (at least a 10-fold decrease was noted [DOE 2003b, Section 5.6.6]). In general, more recent data collected by DOE since the SOWP confirm, with a few exceptions, that a 10-fold dilution factor occurs where the ground water plume is discharging adjacent to the river shoreline. In background locations where elevated ammonia from the Paradox Formation is discharging to the surface water, the 10-fold dilution factor may not apply. This more recent calculation set, *Ground Water/Surface Water Interaction for the Moab, Utah, Site* (DOE 2005b), also provides a more detailed evaluation of the transfer mechanism between ground water and backwater areas.

<u>Implications of Opposing Views on the Appropriate Compliance Standard</u>

If the State's view prevailed, the proposed action for ground water remediation would change only in the duration for which the system would be operated. It is expected that the proposed ground water action would mitigate all impacts to the river within 10 years of implementation and would be operated for 75 years to meet the 3-mg/L ammonia target cleanup goal. Should the target cleanup goal be 0.6 mg/L, the proposed ground water action may need to be operated for at least 200 years. If this were the case, a commensurate increase in annual operation and maintenance costs, generated wastes, and water resource impacts would result for the additional period of operation. Although DOE would commit to completing its cleanup responsibilities in this case, DOE cannot now reasonably assure continued maintenance of active ground water remediation for a time period of 200 years or more. Section 2.6.3 discusses the uncertainty regarding achieving these cleanup goals.

2.7 Other Decision-Making Factors

2.7.1 Areas of Controversy

Several areas of continuing controversy have emerged as a result of DOE's discussions and consultations with cooperating and other agencies or as a result of public comments. Some of these issues and controversies derive directly from technical or regulatory uncertainties. Nontechnical issues and controversies have their origins in policies, perspectives, or positions endorsed by specific agencies or members of the public.

One area of controversy involves the ground water remediation standard to be applied. Based on its calculations, DOE has concluded that protection for aquatic species would be achieved at total ammonia concentrations in surface water of 3 mg/L (acute criteria) and 0.6 mg/L (chronic criteria that assumes dilution within a mixing zone). The USF&WS agrees with DOE that the target goal of 3 mg/L (acute criteria) in ground water that DOE has selected would be protective of aquatic species in the Colorado River.

However, UDEQ disagrees with DOE's selection of the acute standard and has stated that the chronic standard (0.6 mg/L) should be applied to ground water. The consequences of the State's position could lengthen the duration of ground water remediation and are discussed in more detail in Section 2.6.3, "Consequences of Uncertainty," and Section 2.6.4, "Responsible Opposing Views."

There are also some areas of technical disagreement regarding long-term site risks. These risks are associated with uncertainties in processes potentially occurring over hundreds or thousands of years that are not amenable to short-term resolution. For example, professional differences of opinion with the State of Utah on river migration and transport of contaminants under the Colorado River to the Matheson Wetlands Preserve can be resolved with certainty only through long-term monitoring. The potential consequences of these differing opinions with regard to environmental impacts are discussed in Sections 2.6.3 and 2.6.4. While acknowledging these as areas of scientific controversy, DOE does not believe that it is necessary to conclusively resolve these technical controversies before making informed site remediation decisions. DOE will, however, incorporate protocols into its ROD, which will be elaborated on in a subsequent remedial action plan, to require long-term processes to be monitored in a manner that would allow timely remedial action to be taken if DOE's assumptions were subsequently shown to be in error.

DOE recognizes each of these perspectives and, as appropriate, has incorporated them into the analysis of impacts. DOE will take these views into account when it makes its decision on the ultimate disposition of the tailings pile following the issuance of the final EIS.

The primary issue to be resolved is whether to dispose of the Moab uranium mill tailings pile on-site or off-site. If the off-site disposal alternative were selected, DOE must decide which of the three off-site disposal locations should be selected and which mode of transportation (truck, rail, or slurry pipeline) should be used. Ground water remediation would occur under any of the action alternatives. Selection of the No Action alternative for either surface or ground water remediation would not fulfill DOE's obligations under federal law to protect human health and the environment.

2.7.2 National Academy of Sciences Review

The Floyd D. Spence Act required that a remediation plan be prepared to evaluate the costs, benefits, and risks associated with various remediation alternatives, including “removal or treatment of radioactive or other hazardous materials at the site, ground water restoration, and long-term management of residual contaminants.” The Act further stipulated that the draft plan be presented to NAS for review. NAS was directed to provide “technical advice, assistance, and recommendations” for remediation of the Moab site. Under the Act, the Secretary of Energy is required to consider NAS comments before making a final recommendation on the remedy. If the Secretary prepares a remediation plan that is not consistent with the recommendations of the NAS, the Secretary must submit to Congress a report explaining the reasons for deviating from the NAS recommendations.

The *Preliminary Plan for Remediation* (DOE 2001b) was completed in October 2001 and forwarded to NAS. The National Research Council, the chief operating arm of NAS, formed a committee of expert volunteers to review the draft plan and provide technical advice and recommendations for a remedy at the Moab site. The committee held a fact-gathering meeting in Moab on January 14–15, 2002; this meeting included a session for public input. The committee completed its report on June 11, 2002, and conducted a public meeting in Moab and released the report on the same date.

The NAS report concluded that existing scientific and technical data were insufficient to support a decision. Specifically, the committee provided four principal reasons for not selecting a remedial action alternative at the time the report was issued.

The first reason stated that “The pile, the Moab site, and alternative sites for a relocated disposal cell have not been characterized adequately.” Since preparation of the *Preliminary Plan for Remediation*, additional characterization of the tailings pile and the Moab site, which was not available at the time of the NAS review, has been completed and is presented in the SOWP (DOE 2003b). In addition, numerous other reports have been acquired or generated by DOE that are cited as references throughout this EIS and that provide sufficient characterization of the three off-site alternatives to support the analyses in this EIS and future DOE decision-making.

The second reason stated that “Options for implementing the two primary remediation alternatives have not all been identified or sufficiently well defined.” More detailed and complete options for implementing the two primary remediation alternatives, stabilize-in-place or off-site disposal, have been identified and defined in the EIS. For example, three off-site alternatives have been added to the scope of this EIS where, in contrast, the *Preliminary Plan for Remediation* only considered one off-site alternative in any detail. Pre-conceptual facilities configurations, transportation scenarios, and labor and resource requirements have all been defined and presented to support comparative impacts analysis. DOE is confident that the configuration and definition of all the alternatives is much more robust that originally presented in the *Preliminary Plan for Remediation* and sufficient to support sound decision-making. For this reason, the final EIS also serves as the final PFR.

The third reason stated that "Risks, costs, and benefits of the major alternatives have not been adequately characterized and estimated." Human and ecological risks, long- and short-term environmental impacts, costs, and benefits of the major alternatives, which were not completely developed in the *Preliminary Plan for Remediation*, have been fully developed and evaluated in the EIS. These include assessment of potential impacts of catastrophic failure of the disposal cell for the on-site stabilization alternative should DOE's conclusions regarding river migration prove to be incorrect.

The fourth reason stated that "Long-term management implications for each option have not been described." The scope and costs of the long-term stewardship requirements associated with each option have been more fully developed and evaluated in the EIS. Included in this evaluation are the long-term ground water remedial action costs and long-term stewardship costs for annual surveillance and maintenance. The impacts of catastrophic failure should long-term surveillance and engineering controls fail are also included in the EIS to support informed decision-making.

NAS also advised that decisions involving risk management should involve stakeholders from the earliest phases of defining the problem through the final decision. NAS noted that involving the public has particular value at Moab because of the anticipated long duration of the cleanup. To date, DOE's efforts toward public involvement have included public scoping meetings, periodic project update public briefings, publication of project documents on a project website, and presentations to city council meetings. DOE has also included federal and state agencies along with cities, towns, counties, and tribes as cooperating agencies in the development of the EIS through briefings, data submittals to cooperating agencies, and reviews of preliminary drafts. Section 1.6 presents a discussion of these activities and the differing opinions expressed by the cooperating agencies.

In addition, the National Research Council committee recommended further study and evaluation of a wide range of technical areas before DOE makes decisions on the remediation of the Moab site. Table 2–34 presents a summary of these recommendations. NAS did not provide a recommendation on a disposal alternative. Since the issuance of the NAS report, DOE has integrated the NAS recommendations for further study into ongoing site investigations and has used this new knowledge in the analyses performed for this EIS.

NAS has confirmed that its role in the Moab project ended with the issuance of its report, that NAS met its responsibilities under the Act, and that unless directed by Congress, NAS will not be reviewing the EIS (NAS 2004). DOE has considered NAS findings and recommendations in developing this EIS. Specifically, Table 2–34 lists key NAS recommendations, DOE's proposed resolution to findings and recommendations, and the chapter and section of the EIS in which they are addressed.

Table 2–34. Key NAS Recommendations for Assessing Remedial Action Alternatives for the Moab Site

Recommendation	Proposed Resolution	EIS Chapter/Section
Use bounding analysis to frame the major issues.	Incorporate bounding analysis throughout the EIS.	All sections
Evaluate the impacts of a potential failure of the tailings pile.	Include an evaluation of catastrophic failure of a disposal cell at the Moab site.	Chapter 4.0, Section 4.1.17, "Disposal Cell Failure from Natural Phenomena"
Rely on the experience gained from previous DOE projects and the UMTRA Project.	Use overall experience and lessons learned from DOE's uranium mill tailings cleanup programs, especially construction of uranium mill tailings disposal cells, annual inspections of disposal cells, and cleanup of UMTRA Project vicinity properties.	Chapter 2.0, Sections 2.1.1, "Construction and Operations at the Moab Site," 2.1.2, "Characterization and Remediation of Vicinity Properties," 2.1.5, "Resource Requirements"; Chapter 4.0, sections titled "Construction and Operations Impacts at the Moab Site," "Impacts from Characterization and Remediation of Vicinity Properties," "Monitoring and Maintenance Impacts"; and Appendix B, "Assumed Disposal Cell Cover Conceptual Design and Construction."
Improve the understanding of the potential performance of the disposal cell.	Conduct a more detailed evaluation of physical conditions at the proposed disposal sites with respect to geology, soils, climate and meteorology, ground water, and surface water; design a disposal cell that would perform satisfactorily under worst-case conditions at the proposed sites.	Chapter 3.0, Geology—Sections 3.1.1, 3.2.1, 3.3.1, 3.4.1; Soils—Sections 3.1.2, 3.2.2, 3.3.2, 3.4.2; Climate and Meteorology—Sections 3.1.5, 3.2.3, 3.3.4, 3.4.4; Ground Water—Sections 3.1.6, 3.2.4, 3.3.5, 3.4.5; Surface Water—Sections 3.1.7, 3.2.5, 3.3.6, 3.4.6; Appendix B, "Assumed Disposal Cell Cover Conceptual Design and Construction."
Evaluate impacts from institutional controls, including failure.	Evaluate institutional controls with respect to risk to workers and members of the public exposed to contaminants at the proposed disposal sites.	Chapter 4.0, "Human Health"—Sections 4.1.15, 4.2.15, 4.3.15, 4.4.15, 4.1.17, "Disposal Cell Failure from Natural Phenomena"; Appendix D, "Human Health."
Refine the initial cost estimates for the major alternatives.	Provide more detailed cost estimates in 2003 dollars.	Chapter 2.0, Section 2.7.3, "Costs"; Chapter 4.0, "Socioeconomics"—Sections 4.1.14, 4.2.14, 4.3.14, 4.4.14.
Examine the effectiveness of long-term management.	Prepare a risk assessment to evaluate several aspects of the two major alternatives—cap in place and off-site disposal.	Chapter 4.0, "Human Health"—Sections 4.1.15, 4.2.15, 4.3.15, 4.4.15, 4.1.17, "Disposal Cell Failure from Natural Phenomena"; Appendix D, "Human Health."

2.7.3 Costs

To support future decision-making, DOE has estimated the costs of the alternatives analyzed in the EIS (Table 2–35). The estimates, which are in 2003 dollars, include the total costs for surface remediation, ground water remediation, and long-term surveillance and monitoring of the disposal cell. The estimates assume that ground water remediation and long-term surveillance and monitoring would continue for 80 years under the on-site disposal alternative and for 75 years under the off-site disposal alternative, although DOE acknowledges that up to $35,000 in annual costs for disposal cell surveillance and monitoring could continue in perpetuity. The estimates assume implementation of a single work shift schedule; however, the estimates would be essentially the same if a double work shift were implemented because a double shift would not involve overtime costs, but only a compressed schedule for completing the same work. The cost estimate accuracy, as defined by ANSI and the Association for the Advancement of Cost Engineering, is a budget estimate and is expected to fall within the range of –15 percent to +30 percent. However, DOE acknowledges that additional uncertainties, such as land acquisition and impact mitigation costs, are inherent in these estimates. Since the draft EIS, DOE has refined the cost estimates for the Crescent Junction rail alternative. The expected value (mid-range) is now $578 million.

2.7.3.1 On-Site Versus Off-Site Disposal Alternative Comparison

Depending on the off-site disposal cell location and mode of transportation, off-site disposal would cost approximately 63 to 118 percent more than on-site disposal. In absolute terms, off-site disposal would cost approximately $158 million to $294 million more than on-site disposal, depending on the off-site disposal location and mode of transportation.

2.7.3.2 Off-Site Transportation Options Comparison

Among the three transportation options, truck haul would be the least expensive and slurry pipeline the most expensive. The cost difference between rail and slurry pipeline would be less than 2 percent. Truck transportation would cost approximately 10 to 15 percent less than either rail or slurry pipeline.

2.7.3.3 Off-Site Disposal Cell Locations Comparison

The costs for off-site disposal at the Klondike Flats and Crescent Junction sites would be comparable, differing less than 2 percent regardless of the mode of transportation. Consistent with this, the estimates indicate that transport distance is not a key factor in cost for the off-site disposal alternatives. The approximate ratio of the distances of the Klondike Flats, Crescent Junction, and White Mesa Mill sites from the Moab site is 1:1.7:4.7. However, despite the almost 5 times longer distance to White Mesa Mill, truck transportation would cost only 22 percent more for the White Mesa Mill site than for the Klondike Flats site, and slurry transportation would cost only 15 percent more. Nonetheless, the absolute increase in cost under the White Mesa Mill off-site disposal alternative would be substantial. Compared to the cost to ship to the Klondike Flats site, shipping to the White Mesa Mill site would cost $90 million more for truck transport and $71 million more for pipeline transport. In contrast, the absolute increase in cost for the Crescent Junction site over the Klondike Flats site would be only about $3 million to $7 million, depending on the mode of transportation.

2.8 References

10 CFR 1022. U.S. Department of Energy, “Compliance with Floodplain and Wetlands Environmental Review Requirements.”

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